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Appl. No. 10/665,865
Reply to Office Action of June 13, 2005

REMARKS/ARGUMENTS

The claimed invention is a method of producing a high carbon steel sheet by steps required by independent claims 1, 3 and 4. The method requires the use of a steel having the chemical composition specified in JIS G 4051, JIS G 4401 and JIS G 4802 (English version copies are attached for reference).

The present invention method is for use with the specified steel composition and results in a product with superior properties. As explained in detail below, the cited art uses different steps on different composition steel with the result of a different product.

Differences in chemical composition

As shown in the attached materials, the chemical composition of a steel sheet of claims 1, 3 and 4 includes,

(i) as specified in JIS G 4051 and as shown in Table 1, 0.08 to 0.61 mass % C, 0.15 to 0.35 mass % Si, 0.30 to 0.90 mass % Mn, 0.030 mass % or less P, 0.035 mass % or less S, 0.30 mass % or less Cu, 0.20 mass % or less Ni, 0.20 mass % or less Cr; 0.35 mass % or less Ni+Cr;

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(ii) as specified in JIS G 4401 and as shown in Table 1, 0.60 to 1.5 mass % C, 0.35 mass % or less Si, 0.50 mass % or less Mn, 0.030 mass % or less P, 0.030 mass % or less S, 0.25 mass % or less Cu, 0.25 mass % or less Ni, 0.30 mass % or less Cr; or

(iii) as specified in JIS G 4802 and as shown in Table 3, 0.47 to 1.00 mass % C, 0.15 to 0.35 mass % Si, 0.60 to 0.90 mass % Mn, 0.030 mass % or less P, 0.035 mass % or less S, 0.30 mass % or less Cu, 0.20 mass % or less Ni, 0.20 mass % or less Cr.

On the other hand, 0.01 to 0.10 wt% Sb is an indispensable element with the cited reference JP 3-44422 (SUMITOMO METAL IND LTD), whereas Sb is not included in claims 1, 3 and 4 of the present application, JIS G 4051, JIS G 4401 and JIS G 4802.

As mentioned in the English abstract of the cited reference of JP 3-44422, Sb in an amount of 0.01 to 0.10% is added for effectively preventing decarburization on a hot-rolled sheet surface and thereby, descaling becomes unnecessary. That being the case, it is considered that because the steel composition per se is different, even if the processes are same, the cited reference of JP 3-44422 is a disparate patent.

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Differences in processes

Annealing without applying descaling after hot rolling is disclosed in the cited reference JP 3-44422. In contrast, descaling before primary annealing is indispensable for the inventive method (see claims 1, 3 and 4 of the present application). Thus, the present invention differs in terms of processes from the cited reference JP 3-44422. As is explained below, the differences in the processes results in significant differences in quality of the resulting product.

Significance of the differences discussed aboveDifferences in anisotropy Ar of r value

If, to a material steel sheet according to claims 1, 3 and 4, with chemical composition of JIS G 4051, JIS G 4401 or JIS G 4802, of the present application, annealing after hot rolling without applying descaling is effected as in the case of the cited reference of JP 3-44422, because Sb addition is not required in the present invention as disclosed in the present specification and defined in claims 1, 3 and 4, it is considered that decarburization occurs and concentration gradient of carbon grows in the thicknesswise direction of the material steel sheet.

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As discussed in the specification starting at page 10, section (4) "Secondary annealing" conditions, because distribution configuration gives a considerable effect on Δr , even if the secondary annealing specified by claims 1, 3 and 4 is performed in the cited art process, the excellent anisotropy as will be secured with the present application may not be obtained.

Hardness by quenching

If, to a material steel sheet according to claims 1, 3 and 4 with chemical composition, specified by JIS G 4051, JIS G 4401 or JIS G 4802, of the present application, annealing after hot rolling, without applying descaling, is effected as in the method described in the cited reference JP 3-44422, because Sb addition is not prescribed by claims 1, 3 and 4, hardness after quenching of desired HRC 50 or more as obtainable by the present invention may not possibly be achieved. Hardness after quenching of the cited reference of JP 3-44422, as disclosed in Table 2, consists entirely of HRC 41.4 or less.

From the foregoing, it is respectfully submitted that claims 1, 3 and 4 of the present application have differences from the cited reference of JP 3-44422 in terms of not only

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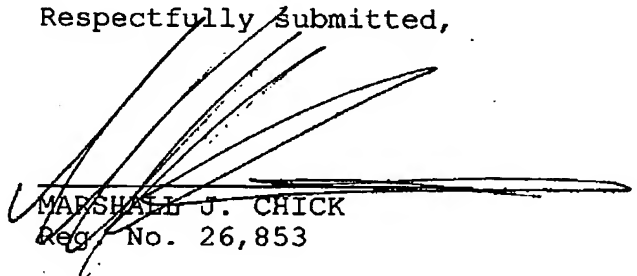
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chemical compositions and processes but also the qualities of the steel sheets resulting from said differences. Consequently, the methods of claims 1, 3 and 4 of the present application are not shown or suggested from the cited reference JP 3-44422.

Allowance of the application is respectfully requested.

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Encs. English translation of JP-3-44422 filed February 26, 1991

Copies of English versions of JIS G 4051, JIS G 4401 and
JIS G 4802 and JIS

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Carbon Steels for Machine

Structural Use

JIS G 4051
(1979)

1. Scope

This Japanese Industrial Standard specifies carbon steels for machine structural use manufactured by hot forming, such as hot rolling or hot forging, ordinarily to be used after further process of forging, cutting and heat treatment, hereinafter referred to as the "steel".

JIS G 3201 and JIS G 3231 are excluded from the above.

2. Classification and Symbols

The steel shall be classified into 23 classes and the respective symbols shall be as given in Table 1. The 3 classes of S 09 CK, S 15 CK and S 20 CK, however, are used for case-hardening purposes.

3. Method of Manufacture

3.1 The steel shall be manufactured from killed steel ingot.

3.2 The steel shall be rolled or forged from steel ingot with forging ratio of not less than 4 S. When the forging ratio of the billet for forging or rolling is less than 4 S, a prior agreement between the purchaser and the manufacturer shall be made.

3.3 Unless otherwise specified, the steel shall be as rolled or forged.

4. Chemical Composition

The chemical composition of the steel shall be determined by the ladle analysis and the value shall be as given in Table 1.

Table 1. Symbol of Class and Chemical Composition

Symbol of class	Chemical composition %				
	C	Si	Mn	P	S
S 09C	0.09 C, 0.13	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 15C	0.10 C, 0.15	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 15CK	0.13 C, 0.18	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 20C	0.15 C, 0.20	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 20CK	0.18 C, 0.23	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 25C	0.20 C, 0.25	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 25CK	0.23 C, 0.28	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 30C	0.25 C, 0.31	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 30CK	0.27 C, 0.32	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 35C	0.20 C, 0.25	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 35CK	0.23 C, 0.28	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 40C	0.25 C, 0.31	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 40CK	0.27 C, 0.32	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 45C	0.40 C, 0.46	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 45CK	0.43 C, 0.48	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 50C	0.45 C, 0.51	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 50CK	0.47 C, 0.53	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 55C	0.50 C, 0.56	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 55CK	0.53 C, 0.61	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 60C	0.57 C, 0.63	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.
S 60CK	0.60 C, 0.68	0.15 C, 0.35	0.20 C, 0.60	0.030 max.	0.03 max.

Remarks 1.

As Impurities, Cu, Ni, Cr and Ni + Cr for Classes S 09 CK, S 15 CK, S 20 CK shall not exceed respectively 0.25 %,

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2. When the product analysis on steel is requested by the purchaser, the tolerance for the product analysis shall conform to Table 2 specified in JIS G 0321.

5.1 Hot Rolled Steel Bar and Wire Rod

5.1.1 Appearance The hot rolled steel bar and the wire rod shall be well finished and free from harmful defects to use in appearance. However, the steel bar which is supplied in coil may include some abnormal portions.

5.1.2 Reference of Flaw Dressing Reference of flaw dressing of the hot rolled steel bar shall be as follows:

- (1) Steel Bar for General Forging The flaw dressing of the steel bar for general forging shall be made smoothly and to the depth not exceeding 4 % of nominal size (3 mm max.) below nominal size, and the total width not exceeding 1/4 of the circumferential length of the same section. If the dressed portion is within the dimensional tolerance, however, it shall not be considered as the flaw of the portion dressed. The permissible amount of remaining flaw shall be as agreed upon between the purchaser and the manufacturer.

- (2) Round Bar for Direct Cutting The permissible depth of flaw on the round bar for direct cutting shall conform to the value given in Table 2 deducted from the nominal size.

Table 2. Permissible Depth of Flaw of Round Bar for Direct Cutting (Hot Rolled Steel Bar)

Diameter mm	Permissible depth of flaw
Under 16	Not exceeding 4 % of nominal size with the maximum of 0.5 mm
16 to 50 excl.	Not exceeding 3 % of nominal size with the maximum of 1.0 mm
50 to 100 excl.	Not exceeding 2 % of nominal size with the maximum of 1.5 mm
100 and over	Not exceeding 1.5 % of nominal size with the maximum of 3.0 mm

- (3) Steel Bar for Cold Drawing The flaw dressing of the steel bar for cold drawing shall be made smoothly and the permissible limit in repair shall conform to the value given in Table 3 deducted from the permissible minimum size.

5.1.3 Standard Dimension The standard dimensions of the hot rolled steel bar (round, square, hexagonal) and wire rod shall conform to Table 4.

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Table 3. Permissible Limit in Repair of Steel Bar for Cold Drawing (Hot Rolled Steel Bar)

Diameter or width across flats mm	Permissible limit in repair
Under 16	0.15 mm
16 to 50 excl.	Not exceeding 1 % of nominal size with the maximum of 0.35 mm
50 to 100 excl.	Not exceeding 0.7 % of nominal size with the maximum of 0.50 mm
100 to 130 incl.	Not exceeding 0.5 % of nominal size

Table 4. Standard Dimensions of Hot Rolled Steel Bar and Wire Rod

Round bar Diameter mm	Round bar Width across flats mm	Hexagonal bar Width across flats mm	Hexagonal bar Width across flats mm	Unit: mm
(10) 10	10	10	10	
(12) 12	12	12	12	
(14) 14	14	14	14	
(16) 16	16	16	16	
(18) 18	18	18	18	
(20) 20	20	20	20	
(22) 22	22	22	22	
(24) 24	24	24	24	
(26) 26	26	26	26	
(28) 28	28	28	28	
(30) 30	30	30	30	
(32) 32	32	32	32	
(34) 34	34	34	34	
(36) 36	36	36	36	
(38) 38	38	38	38	
(40) 40	40	40	40	
(42) 42	42	42	42	
(44) 44	44	44	44	
(46) 46	46	46	46	
(48) 48	48	48	48	
(50) 50	50	50	50	
(52) 52	52	52	52	
(54) 54	54	54	54	
(56) 56	56	56	56	
(58) 58	58	58	58	
(60) 60	60	60	60	
(62) 62	62	62	62	
(64) 64	64	64	64	
(66) 66	66	66	66	
(68) 68	68	68	68	
(70) 70	70	70	70	
(72) 72	72	72	72	
(74) 74	74	74	74	
(76) 76	76	76	76	
(78) 78	78	78	78	
(80) 80	80	80	80	
(82) 82	82	82	82	
(84) 84	84	84	84	
(86) 86	86	86	86	
(88) 88	88	88	88	
(90) 90	90	90	90	
(92) 92	92	92	92	
(94) 94	94	94	94	
(96) 96	96	96	96	
(98) 98	98	98	98	
(100) 100	100	100	100	

Remark: It is desirable to avoid using figures in parentheses.

- (1) The shape and dimensional tolerances of the hot rolled round bar and the square bar shall conform to Table 5.

Table 5. Shape and Dimensional Tolerances of Hot Rolled Round Bar and Square Bar

Item	Shape and dimensional tolerance
Tolerances on diameter or width across flats	$\pm 1.5 \%$ with the minimum value of 0.4 mm
Deviation of diameter or deviation	Not exceeding 70 % of range of tolerance on diameter or width across flats
Tolerances on length	For length not exceeding 7 m: ± 40 mm For length exceeding 7 m: Add 5 mm to plus side tolerance for every increase of 1 m or its fraction
Radius on corners (R)	10 to 20 % of width across flats, as a rule
Twist	To be practically straight
Band	Not exceeding 3 mm for every 1 m and not exceeding 3 mm x length (m)/1 m for total length

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- (2) The shape and the dimensional tolerances on the hot rolled hexagonal bar shall conform to Table 6.

Table 6. Shape and Dimensional Tolerances on Hot Rolled Hexagonal Bar

Item	Width across flats	Tolerance on width across flats	Deviation of width across flats
(12)	13	± 0.7	1.0 max.
14	17		
19 22 24		± 0.8	1.1 max.
27 30			
32 36 41		± 1.0	1.4 max.
46 50			
55 60 63			
67 71 (75)		± 1.2	1.7 max.
(77) (81)			

Tolerances and deviation on width across flats

mm

Tolerance on length	For length not exceeding 7 m	+ 40 mm
	For length exceeding 7 m	
	For length exceeding 7 m	Add 5 mm to plus side tolerance for every increase of 1 m or its fraction

Twist To be practically straight

Bend Not exceeding 3 mm for every 1 m and not exceeding 3 mm x length(m)/1m for total length

Remark: It is desirable to avoid using figures in parentheses.

- (3) The dimensional tolerances on the hot rolled wire rod shall conform to Table 7.

Table 7. Dimensional Tolerances on Hot Rolled Wire Rod

Diameter	Tolerances on dia.	Deviation
Under 16	± 0.4	0.5 max.
16 and over	± 0.5	0.6 max.

5.2 Hot Rolled Plate, Sheet and Strip

5.2.1 Appearance The appearance of the hot rolled steel plate, sheet and strip shall conform to 7, specified in JIS G 3193.

5.2.2 Reference of Flaw Dressing The reference of flaw dressing of the hot rolled steel plate and sheet shall conform to 7, specified in JIS G 3193. However, the application of reworking by welding and the permissible amount of remaining flaws shall be as agreed upon between the purchaser and the manufacturer.

5.2.3 Standard Dimension The standard dimension of the hot rolled steel plate, sheet and strip shall be as given in (1) and (2).

- (1) The standard thickness of the hot rolled steel plate, sheet and strip shall conform to 4.1 specified in JIS G 3193.

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- (2) The standard width and length of the hot rolled steel plate, sheet and strip shall conform to 4.2 and 4.3 specified in JIS G 3193.

5.2.4 Shape and Dimensional Tolerances The shape and dimensional tolerances of the hot rolled steel plate, sheet and strip shall be as given in (1) and (2).

- (1) The shape and dimensional tolerances of the hot rolled steel plate, sheet and strip shall conform to 5, specified in JIS G 3193. In this case, the tolerances on thickness apply to those under 160 mm. However, in the case of 160 mm and over, it shall be agreed upon between the purchaser and the manufacturer.
- (2) The permissible maximum values for flatness of the hot rolled steel plate and sheet shall be as given in (a) to (c).
- (a) The steel plate and sheet (S 10 C to S 23 C) of the thickness under 160 mm shall conform to 5.5 specified in JIS G 3193.
- (b) The steel plate and sheet (S 28 C to S 38 C) of the thickness under 160 mm shall conform to Table 8.
- (c) The steel plate and sheet of the thickness 160 mm and over shall be as agreed upon between the purchaser and the manufacturer.

Table 8. Permissible Maximum Values for Flatness of Hot Rolled Steel Plate and Sheet (S 28 C to S 38 C)

Thickness	Width					
	Under 1250	1250 to 1600 excl.	1600 to 2000 excl.	2000 to 2500 excl.	2500 to 3000 excl.	3000 and over
Under 1.60	27	30	—	—	—	—
1.60 to 4.00 excl.	24	27	30	—	—	—
4.00 to 6.30 excl.	21	24	27	33	39	42
6.30 to 10.0 excl.	18	21	24	30	36	39
10.0 to 25.0 excl.	15	18	21	24	27	30
25.0 to 63.0 excl.	12	15	18	21	24	27
63.0 to 160 excl.	12	12	15	18	21	24

Unit: mm

Remarks 1. Not applicable to steel plate and sheet supplied after treated with stretch leveler.

2. The above Table shall be applicable to any 4000 mm in length of steel plates and sheets, and to full length of plates and sheets under 4000 mm in length.
3. The values for flatness of steel plates and sheets shall be measured from the maximum warping of the upper surface of the plates by reducing the thickness thereof.
4. Not applicable to as rolled steel plates and sheets having rims.
5. The measurement of flatness of steel plates and sheets shall generally be done on a surface plate.

5.3 Hot Rolled Flat Steel

5.3.1 Appearance The hot rolled flat steel shall be free from injurious defects to use in appearance.

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5.3.2 Reference of Flaw Dressing The reference of flaw dressing on the hot rolled flat steel shall conform to (1) and (2) of 6.2.1 specified in JIS G 3194.

5.3.3 Standard Dimension The standard dimension of the hot rolled flat steel shall conform to 4. specified in JIS G 3194.

5.3.4 Shape and Dimensional Tolerances The shape and dimensional tolerances of the hot rolled flat steel shall conform to 5. specified in JIS G 3194.

5.4 The appearance, reference of flaw dressing, shape, dimension and dimensional tolerances on steel other than those specified in 5.1, 5.2 and 5.3 shall be as agreed upon between the purchaser and the manufacturer.

6. Test

6.1 The general requirements for the chemical analysis and the method of sampling for the ladle analysis shall comply with 3. specified in JIS G 0303.

6.2 The method of sampling for the product analysis shall comply with 3. specified in JIS G 0321.

6.3 The method of analysis shall conform to the requirements specified in either of the following standards:

JIS G 1211	JIS G 1212	JIS G 1213	JIS G 1214
JIS G 1215	JIS G 1216	JIS G 1217	JIS G 1219
JIS G 1252	JIS G 1253	JIS G 1256	JIS G 1257

7. Inspection
7.1 The general requirements for the inspection shall comply with JIS G 0303.

7.2 The results of inspection for the chemical composition, the appearance, the shape and dimensions shall satisfy the requirements specified in 4. and 5.

7.3 Besides the inspection and tests specified in 7.2, the purchaser may designate the inspection and tests given below. In this case, the purchaser shall have prior agreement with the manufacturer upon inspection items, method of sampling, test method and the criteria of acceptance or rejection.

Magnetic particle inspection⁽¹⁾, ultrasonic inspection⁽²⁾, decarburization inspection⁽³⁾, nonmetallic inclusions inspection⁽⁴⁾, grain size inspection⁽⁵⁾, mechanical properties inspection⁽⁶⁾, hardenability inspection⁽⁷⁾, macrostructure detecting inspection⁽⁸⁾, macro-streak (flaw inspection⁽⁹⁾) and microscopic structure inspection.

Notes (1) This shall conform to JIS G 0565.

(2) This shall conform to JIS Z 2344.

(3) This shall conform to JIS G 0358.

(4) This shall conform to JIS G 0555.

(5) This shall conform to JIS G 0551.

(6) This shall conform to JIS Z 2201, JIS Z 2241, JIS Z 2202, JIS Z 2242 and JIS Z 2243.

(7) This shall conform to JIS G 0561.

(8) This shall conform to JIS G 0553. However, this standard shall apply mainly to the steel bar.

(9) This shall conform to JIS G 0556. However, this standard shall apply mainly to the steel bar.

8. Marking

8.1 Flat Steel, Steel Bar and Wire Rod The marking on each flat steel, steel bar and wire rod shall be done with the following items by a suitable method. The flat steel and the steel bar under 30 mm in diameter or width across flats may be bound up, and the marking may be made on each bundle by a suitable method. A part of following particulars may be omitted when agreed upon by the purchaser.

(1) Symbol of class

(2) Heat No. or other manufacturing No.

(3) Name of manufacturer or its abbreviation

8.2 Steel Plate, Sheet and Strip The marking on the steel plate, sheet and strip shall be done with the following items by a suitable method on each steel or bundle. A part of following particulars may be omitted when agreed upon by the purchaser.

(1) Symbol of class

(2) Heat No. or other manufacturing No.

(3) Dimension

(4) Name of manufacturer or its abbreviation

9. Report

The report shall conform to 8. specified in JIS G 0303. Submitting of test results specified in 7.3, however, shall be made after the agreement between the purchaser and the manufacturer.

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11. Inspection

The inspection shall be as follows:

- (1) General matters of inspection shall be as specified in JIS G 0303.
- (2) The test results on chemical composition, mechanical properties, surface finish, austenitic grain size, shape, dimensions and appearance shall conform to 3, 4, 5, 6, 7, and 8. However, part or all of tensile test and hardness test may be omitted by agreement between the parties concerned.
- (3) The purchaser may additionally require high temperature tensile test, ultrasonic examination and liquid penetrant examination. However, the test methods in this case shall be in accordance with one of the following Standards and the acceptance criteria shall be preliminarily agreed upon by the purchaser and the manufacturer.

JIS G 0567 JIS Z 2343 JIS Z 2344

12. Marking

The plates and sheets having passed the inspection shall be marked on each plate and sheet or each bundle (package) with the following information. However, part of them may be omitted when approved by the purchaser.

- (1) Symbol of type
- (2) Heat number or inspection number
- (3) Dimensions
- (4) Symbol of surface finish
- (5) Symbol of heat treatment (1)
- (6) Manufacturer's name or mark

Further, symbols B and BF of thickness and flatness tolerances shall be clearly indicated.

Note (1) The symbol of heat treatment shall be as follows, and shall be suffixed to the symbol of type.

Solution treatment	S, SI, SZ
Annealing	A
Aging treatment after solution treatment	H, H1, H2

13. Report

The manufacturer shall submit to the purchaser a report of plates and sheets carrying the results of tests specified or designated and, as required, a report on dimensions, quantity, condition of heat treatment, delivery condition, etc.

Further, when alloying elements are added according to Remark of Table 2, the contents of alloying elements shall be appended to the report on test results.

Carbon Tool Steels*

JIS G 4401
(1987)1. Scope

This Japanese Industrial Standard specifies the carbon tool steels, hereinafter referred to as the "steels", manufactured by hot-rolling or forging.

2. Grade and Designation

The steels shall be classified into 7 grades and the designation shall be as given in Table 1.

3. Method of Manufacture

3.1 The steel shall be made of killed steel.

3.2 Unless otherwise specified, the steel shall be rolled or forged with a forming ratio of 45 and over. However, if the forming ratio is difficult to attain 45 owing to the dimension of the steel, it may be overcome by upset forging.

3.3 Unless otherwise specified, the steel shall be subjected to annealing. The plate and sheet in coils and cut lengths, however, shall be as rolled, unless otherwise specified.

4. Chemical Composition

The chemical composition of the steel shall be determined by the ladle analysis, and the values obtained shall conform to Table 1.

5. Hardness in Annealed Condition

The annealed hardness for the steel shall conform to Table 2. Pertaining to the steel for which the measurement by Brinell hardness is difficult, however, it may be made by Rockwell B hardness or Vickers hardness. In this case, the value of Rockwell B or Vickers hardness shall be agreed upon between the purchaser and the manufacturer.

6. Hardness in Quenched and Tempered Condition

The test piece which is the representative of the steel to be quenched and tempered shall be subjected to heat treatment at an appropriate temperature range selected among those as given in Table 3. And the hardness on the test piece in quenched and tempered condition shall conform to Table 3.

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Table 1. Chemical Composition

Designation of grade	Chemical composition %					Example of application for reference
	C	Si	Mn	P	S	
SK 1	1.10 to 1.50	0.35 max.	0.50 max.	0.030 max.	0.030 max.	Blade file, file set
SK 2	1.10 to 1.30	0.35 max.	0.50 max.	0.030 max.	0.030 max.	Drill, small punch, razor, file, cutting tool, hacksaw and spiral spring
SK 3	1.00 to 1.10	0.35 max.	0.50 max.	0.030 max.	0.030 max.	Hacksaw, bit, gauge, spiral spring, die for press, jig and tool, and cutting tool
SK 4	0.90 to 1.00	0.35 max.	0.50 max.	0.030 max.	0.030 max.	Drill for wood working, hatchet, bit, spiral spring, pen nib, chisel, scribe knife, die for press, gauge and latch needle
SK 5	0.80 to 0.90	0.35 max.	0.50 max.	0.030 max.	0.030 max.	Steel stamp, die for press, spiral spring, band saw, jig and tool, cutting tool, circular saw, mineograph file, gauge and needle
SK 6	0.70 to 0.80	0.35 max.	0.50 max.	0.030 max.	0.030 max.	Steel stamp, snap, circular saw, spiral spring, mineograph file and die for press
SK 7	0.60 to 0.70	0.35 max.	0.50 max.	0.030 max.	0.030 max.	Steel stamp, snap, die for press and knife

Remark: The content of Cu, Cr and Ni for each grade shall not exceed 0.25 %, 0.30 % and 0.25 %, respectively, as the impurities.

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Table 2. Annealed Hardness of Steel

Designation of grade	Annealing temperature °C	Annealed HB hardness
SK 1	750 to 760 slow cooling	217 max.
SK 2	750 to 760 slow cooling	212 max.
SK 3	750 to 760 slow cooling	212 max.
SK 4	740 to 760 slow cooling	207 max.
SK 5	730 to 760 slow cooling	207 max.
SK 6	730 to 760 slow cooling	201 max.
SK 7	730 to 760 slow cooling	201 max.

Remark: For hot-rolled steel plate and sheet in coils and cut lengths, the hardness value as rolled or in annealed condition shall be agreed upon between the purchaser and the manufacturer.

Table 3. Quenched and Tempered Hardness of Test Piece

Designation of grade	Heat treatment temperature °C		Quenched and tempered hardness HRC
	Quenching	Tempering	
SK 1	760 to 820 water cooling	150 to 200 air cooling	63 min.
SK 2	760 to 820 water cooling	150 to 200 air cooling	63 min.
SK 3	760 to 820 water cooling	150 to 200 air cooling	63 min.
SK 4	760 to 820 water cooling	150 to 200 air cooling	61 min.
SK 5	760 to 820 water cooling	150 to 200 air cooling	59 min.
SK 6	760 to 820 water cooling	150 to 200 air cooling	57 min.
SK 7	760 to 820 water cooling	150 to 200 air cooling	56 min.

Remark: For the steel which have not been annealed, it shall be subjected to annealing according to Table 2 and subsequently quenching and tempering.

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7. Appearance, Shape, Dimensions and Tolerances**7.1 Hot-rolled Round Steel Bar**

7.1.1 Appearance The hot-rolled round steel bar shall have a well workmanlike finish, and shall be free from defects that are detrimental to practical use.

7.1.2 Preferred Dimension The preferred diameter of the hot-rolled round steel bar shall be as given in Table 4.

Table 4. Preferred Diameter

Unit: mm				
10	20	30	50	100
11	21	32	55	110
12	22	34	60	120
13	23	36	65	130
14	24	38	70	140
15	25	40	75	150
16	26	42	80	
17	27	44	85	
18	28	46	90	
19	29	48	95	

7.1.3 Dimensional Tolerances The tolerances on diameter for the hot-rolled round steel bar shall conform to Table 5.

Table 5. Tolerances on Diameter.

Unit: mm		
Specified diameter	Tolerance on diameter	Permissible deviation on ovality.
10 and over, up to 16	+ 0.6 - 0.3	
16 and over, up to 30	+ 0.7 - 0.3	Up to and incl. 70 % of the full range of tolerance on diameter
30 and over, up to and incl. 150	+ 2.5 % - 1.0 %	

Remark: The tolerances on diameter for the round steel bar whose diameter is up to 10 mm or over 150 mm shall be agreed upon between the purchaser and the manufacturer.

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7.2 Hot-rolled Steel Plate and Sheet in Coils and Cut Lengths

7.2.1 Appearance The appearance of the hot-rolled steel plate and sheet in coils and cut lengths shall be in accordance with 7. in JIS G 3193.

7.2.2 Preferred Dimension The preferred dimension of the hot-rolled steel plate and sheet in coils and cut lengths shall conform to (1) and (2) of the following:

- (1) The preferred thickness of the hot-rolled steel plate and sheet in coils and cut lengths shall be in accordance with 4.1 in JIS G 3193.
- (2) The preferred width and length of the hot-rolled steel plate and sheet in coils and cut lengths shall be in accordance with 4.2 and 4.3 in JIS G 3193.

7.2.3 Tolerances on Shape and Dimension The tolerances on shape and dimension for the hot-rolled steel plate and sheet in coils and cut lengths shall conform to (1) and (2) of the following:

- (1) The tolerances on shape and dimension for the hot-rolled steel plate and sheet in coils and cut lengths shall conform to 5. in JIS G 3193. In this case, the thickness tolerances shall be applied to those up to not including 160 mm in thickness, and for plates thicker than 160 mm, it shall be agreed upon between the purchaser and the manufacturer.
- (2) The upper limit of flatness tolerances for hot-rolled steel plate and sheet in cut lengths shall conform to (a) and (b) of the following:
 - (a) The tolerances for the steel plate and sheet up to 160 mm in thickness shall conform to Table 6.
 - (b) The tolerances for the steel plate 160 mm and over in thickness shall be the subject of agreement between the purchaser and the manufacturer.

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JIS G 4802
(1993)

Cold-rolled Steel Strips for Springs*

1. Scope

This Japanese Industrial Standard specifies the cold-reduced steel strips, hereinafter referred to as the "strips", mainly used for the flat spring and spiral spring. Furthermore, this standard shall also be applied to the strips in cut lengths.

2. Grade and Designation

The strips shall be classified into 8 grades as given in Table 1, and further, each grade shall be subclassified according to the temper grade as given in Table 2. The letter symbol that is the temper designation shall be suffixed to that of grade to compose the designation system of the strip.

Example: SK 5-CSPA

Table 1. Designation of Grade		Table 2. Temper Grade and Letter Symbol	
Designation		Temper grade	Temper designation
S 50 C - CSP		Annealed	A
S 55 C - CSP		As cold-reduced	R
S 60 C - CSP		Quenched and tempered	H
S 65 C - CSP		Auttempered	B
S 70 C - CSP			
SK 5 - CSP			
SK 4 - CSP			
SUP 10 - CSP			

3. Method of Manufacture

The strips shall be obtained from hot-rolled steel sheets or strips by cold-reducing or subsequently heat treating.

4. Chemical Composition

The chemical composition of the strip shall be determined by the ladle analysis, and the values obtained shall be as given in Table 3.

5. Hardness

5.1 The hardness of the strip for temper designation "A" shall be as given in Table 4.

Table 3. Chemical Composition

Designation of Grade	Chemical composition %									
	C	Si	Mn	P	S	Ca	Al	Cr	Ni+Cu	V
S 50 C - CSP	0.47 to 0.53	0.15 to 0.35	0.40 to 0.90	0.010 max.	0.015 max.	0.10 max.	0.20 max.	0.10 max.	0.15 max.	-
S 55 C - CSP	0.52 to 0.58	0.15 to 0.35	0.40 to 0.90	0.010 max.	0.015 max.	0.10 max.	0.20 max.	0.10 max.	0.15 max.	-
S 60 C - CSP	0.55 to 0.65	0.15 to 0.35	0.40 to 0.90	0.010 max.	0.015 max.	0.10 max.	0.20 max.	0.10 max.	0.15 max.	-
S 65 C - CSP	0.60 to 0.70	0.15 to 0.35	0.40 to 0.90	0.010 max.	0.015 max.	0.10 max.	0.20 max.	0.10 max.	0.15 max.	-
S 70 C - CSP	0.65 to 0.75	0.15 to 0.35	0.40 to 0.90	0.010 max.	0.015 max.	0.10 max.	0.20 max.	0.10 max.	0.15 max.	-
SK 5 - CSP	0.40 to 0.50	0.15 to 0.35	0.40 to 0.90	0.010 max.	0.015 max.	0.10 max.	0.20 max.	0.10 max.	0.15 max.	-
SK 4 - CSP	0.30 to 0.40	0.15 to 0.35	0.40 to 0.90	0.010 max.	0.015 max.	0.10 max.	0.20 max.	0.10 max.	0.15 max.	-
SUP 10 - CSP	0.45 to 0.55	0.15 to 0.35	0.40 to 0.90	0.010 max.	0.015 max.	0.10 max.	0.20 max.	0.10 max.	0.15 max.	-

Remark: When the product analysis of the strip is made according to the request of the purchaser, the tolerance for the product analysis shall conform to Table 2 and Table 3 specified in JIS G 0321.

Table 4. Hardness

Designation	A (HV)
S 50 C - CSP	180 max.
S 55 C - CSP	180 max.
S 60 C - CSP	190 max.
S 65 C - CSP	190 max.
S 70 C - CSP	190 max.
SK 5 - CSP	190 max.
SK 4 - CSP	200 max.
SUP 10 - CSP	190 max.

Remark: The dispersion of hardness within one strip shall fall in the range of 30 HV.

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5.2 The hardness (mid-value) of the strip for temper designation "R", "H" and "B" may be specified to fall within the range given in Table 5. In this case, the tolerance on each specified hardness shall be \pm HV 20 for the strip of temper designation "R", and \pm HV 15 for "H" and "B", respectively.

Table 5. Range of Hardness (Mid-value) Which May Be Specified

Designation of grade	R (HV)	H (HV)	B (HV)
S 50 C - CSP	230 to 270	-	360 to 440
S 55 C - CSP	230 to 270	350 to 450	360 to 440
S 60 C - CSP	230 to 270	350 to 500	360 to 440
S 65 C - CSP	230 to 270	-	-
S 70 C - CSP	230 to 270	350 to 550	-
SK 3 - CSP	230 to 270	350 to 600	-
SK 4 - CSP	230 to 270	400 to 600	-
SUP 10 - CSP	230 to 270	-	-

Remark: The dispersion of hardness within one strip shall fall in the range of 30 HV.

6. Surface Condition

The strip shall have smooth surface and shall be free from decarburization, strain, rust, flaw, peeling, edge crack and other defects that are detrimental.

7. Internal Soundness

7.1 The microstructure of the strips for temper designation "H" and "B" shall have, as a rule, uniform distribution of spheroidized carbide, free from residual of carbide network, and shall be free from non-metallic inclusions and segregations that are detrimental.

7.2 The strips for temper designation "H" and "B" shall be free from non-metallic inclusions and segregations that are detrimental.

8. Shape, Dimension and Tolerances

8.1 The preferred thickness of the strip and the tolerances shall be as given in Table 6.

When the tolerances of symbolized ET is necessary, however, this shall be specified by the purchaser.

The thickness shall be measured at any point on the strip not less than 10 mm from a side edge, while, for the strip less than 20 mm in width, the measurement shall be made at the midway of width. When designated the tolerance of symbolized ET, however, the purchaser may specify the measuring point of thickness.

Table 6. Preferred Thickness and Tolerances

Unit: mm

Preferred thickness	Specified thickness range	Tolerance		Tolerance (Symbol ET)
		Up to 300 in width	300 and over, up to 500 in width	Up to 50 in width
0.10 and over,	Up to 0.10	± 0.008	-	± 0.008
0.10 and over,	Up to 0.15	± 0.010	-	± 0.008
0.15 and over,	Up to 0.25	± 0.015	± 0.020	± 0.010
0.25 and over,	Up to 0.40	± 0.020	± 0.025	± 0.015
0.40 and over,	Up to 0.60	± 0.025	± 0.030	± 0.020
0.60 and over,	Up to 0.80	± 0.030	± 0.040	± 0.025
0.80 and over,	Up to 1.00	± 0.040	± 0.050	± 0.035
1.00 and over,	Up to 1.60	± 0.050	± 0.060	-
1.60 and over,	Up to 2.00	± 0.060	± 0.070	-
2.00 and over,	Up to 3.00	± 0.075	± 0.090	-
3.00 and over,	Up to 4.00	± 0.090	± 0.100	-

Remark: Since there is no restriction in the range of manufacturing capability for the strips of temper designation "H" and "B", the applicable range of the size for these strips shall be agreed upon between the purchaser and the manufacturer.

8.2 The width tolerances for the strip of slitted edge shall be as given in Table 7.

Table 7. Tolerances on Width

Unit: mm

Specified thickness	Specified width	Tolerance on width		
		Up to 80	80 and over, up to 200	200 and over, up to 500
0.25 and over,	Up to 0.60	± 0.10	± 0.15	± 0.25
0.60 and over,	Up to 1.20	± 0.15	± 0.20	± 0.30
1.20 and over,	Up to 4.00	± 0.20	± 0.25	± 0.40

Remark: The width tolerances for the strips up to 0.25 mm in thickness and of temper designation "H" and "B" shall be agreed upon between the purchaser and the manufacturer.

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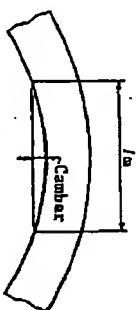
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8.3 The camber (') for the strip shall not exceed the values given in Table 8 in any 1 m length.

Table 8. Permissible Maximum Value on Camber

Temper designation	Camber, in any 1 m length					Unit: mm
	Specified width	5 and over, up to 10	10 and over, up to 20	20 and over, up to 40	40 and over, up to 80	
A and R		-	8	6	3	1
B		-	5	5	2	1
H		2	2	2	2	1

Note (') The camber for the strip is defined as a curvature along the longitudinal direction in both sides, and shall be measured as shown in the figure. In this case, however, it shall not apply to each 1 m length of both coil ends.



Remarks 1. The permissible maximum value on camber for the strips up to 10 mm in width of temper designation "A", "R" and "H" and for the strips up to 5 mm in width of temper designation "B" shall be agreed upon with the purchaser and the manufacturer.

2. When the width of the strip of temper designation "A" and "R" is 10 mm and over to up to 20 mm, the permissible maximum value on camber shall be applied only for the strip whose width (W) to thickness (T) ratio $\frac{W}{T}$ is 10 and over.

8.4 The tolerances on length for the strip in cut length shall conform to Table 9.

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Table 9. Length Tolerances for Strip in Cut Length

Specified length	Length tolerance		Unit: mm
	Specified width	Up to 200	
Up to 2000		+5	200 and over, up to 500
2000 and over, up to 4000		+10	+10
		0	0
		+10	+20
		0	0

Remark: The values of length tolerance mentioned above shall be applied to the strip 0.5 mm and over in thickness.

9. Test

9.2 Hardness Test The hardness test method shall comply with JIS Z 2244.

10. Inspection

10.1 The general requirements for inspection shall conform to JIS G 0303. One or more test specimen for hardness test shall be taken from each lot of the strip of the same heat rolled to the same thickness and tempered under the same conditions, then one test piece shall be prepared from each test specimen.

10.2 The test results on chemical composition, hardness, appearance, internal soundness, shape and dimension shall conform to the requirements specified in 4. to 8. inclusive.

11. Marking

The strip having passed the inspection shall be legibly marked the following items on each package by suitable means. However, the "weight" may be marked on each lot for shipment.

- (1) Designation of grade and temper designation
- (2) Dimension
- (3) Weight
- (4) Manufacturer's name or its identifying brand

When the tolerances of symbolized ET is specified, this matter shall be legibly marked.

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